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(पहला पुनरीक्षण)

Indian Standard

AUTOMOTIVE VEHICLES – STARTING GRADEABILITY – METHOD OF MEASUREMENT

(First Revision)

ICS 43.020, 19.060

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

September 2002

Price Group 3

Automotive Vehicles Testing and Performance Evaluation Sectional Committee, TED 8

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Automotive Vehicles Testing and Performance Evaluation Sectional Committee had been approved by the Transport Engineering Division Council.

This standard was first published in 1994. This revision has been taken up to include the requirements of:

a) measurement of air density at the site conditions,

b) the length of the gradient in the test track, and

c) the technical specification of the vehicle to be submitted to the Testing Agency (*see* Annex A) for gradeability test.

The composition of the Committee responsible for the formulation of this standard is given in Annex B.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2:1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

AUTOMOTIVE VEHICLES – STARTING GRADEABILITY – METHOD OF MEASUREMENT

(First Revision)

1 SCOPE

This standard specifies the method for measurement of starting gradeability for all types of road vehicles and may also be used to verify the capability of vehicle with the maximum recommended gradeability declared by the vehicle manufacturer.

2 TERMINOLOGY

2.1 Starting Gradeability—The starting gradeability of a vehicle is the maximum gradient, on which the vehicle can start climbing from stand-still condition, with all the wheels of the vehicle on the gradient at the time of start.

2.2 Percentage Gradient—It is 100 × tan θ, where 'θ' is the angle between the gradient and horizontal plane.

3 VEHICLE PREPARATION

3.1 The vehicle shall be run in as per the practice recommended by the vehicle manufacturer.

3.2 The vehicle shall conform in all its parts, components and systems to the technical specification declared by the manufacturer.

3.3 The adjustment of brakes, clutch, idling speed, etc, and the adjustment of fuel system, ignition system and grade, quality, quantity of lubricants for various moving parts shall conform to the manufacturer's recommendation.

3.4 The tyres shall be run in at the same time as the vehicle and shall have a tread depth not less than 90 percent of tread depth of a new tyre and shall have operated for at least 500 km or the distance recommended for running-in of the vehicle, prior to test.

3.5 The tyre pressure shall be adjusted, when cold, to the value recommended by the vehicle manufacturer for that load condition of the vehicle.

3.6 All the fuel enriching devices other than those required for the normal functioning of the vehicle shall be made inoperative.

3.7 Additional attachments which consume power like air-conditioner, etc, shall also be made inoperative.

3.8 In case of vehicle with more than one live axle, all combinations of live axles provided for selection on the vehicle shall be tried out.

3.9 The vehicle shall be loaded to the specified gross vehicle weight (GVW) and load distribution between the axles shall be as close as possible to the values recommended by the manufacturer.

3.10 Before test, vehicle including all its parts, components and systems shall have reached a stable operating temperature normal to the vehicle preparation.

3.11 During testing all the windows and ventilating systems of the cabin shall be closed and overhead ventilating system/hatches where provided shall be lowered, wherever applicable.

4 TEST CONDITIONS

4.1 Atmospheric Conditions

4.1.1 The atmospheric conditions at test site, such as pressure, temperature and relative humidity shall be recorded. The air density at test site (d_t) shall be calculated by the formula given below. The air density so calculated shall not differ from the reference air density (d_o) by more than 7.5 percent.

$$d_t = d_o \times (H_t/H_o) \times (T_o/T_t)$$

where

d_t = air density at test conditions in kg/m^3,
d_o = air density at reference conditions = 1.168kg/m^3,
H_t = atmospheric pressure at test site expressed in kPa,
H_o = atmospheric pressure at reference conditions = 100 kPa,
T_o = ambient temperature at reference conditions = 300 K, and
T_t = ambient temperature at test site expressed in K.

4.1.2 The relative humidity at the test site shall be between 45 and 75 percent.

4.2 Features of Test Track

4.2.1 The surface of the test track shall be dry, roadway covered with asphalt or concrete. The lateral gradient of the track shall not exceed 3 percent. The length of the gradient shall be at least equal to the wheel base of the vehicle plus 15 metres.

4.2.2 The inclination of stretch on which the trials are conducted shall be measured at least at three places and the average angle of these values shall be quoted as gradient.

5 TEST PROCEDURE

5.1 The test shall be conducted preferably on the specified gradient. If such a gradient is not available, the nearest gradient available shall be used. Park the vehicle on the gradient using parking brake, front of the vehicle facing upwards with all the wheels standing on the gradient and the rearmost point of the vehicle lies at least one metre ahead of the bottom of the gradient. If necessary, wheel chock may also be placed behind the rearmost wheels. In case of two wheelers, the vehicle shall be parked as above by using the front/rear brake or by using the wheel chock behind the rear wheel.

5.2 The vehicle shall be started from neutral gear position with engaging of the lowest gear (that is, the gear with highest numerical reduction ratio). Attempt shall be made to start the vehicle in this position.

5.3 In case, the test is done on a gradient which is not the specified gradient, increase/decrease the load in/on the vehicle till the vehicle is just capable of starting and negotiating the gradient. This shall be possible without excessive shuddering or vibration of the vehicle. Record the weight of vehicle at this condition. The test shall be repeated three times successfully. In all three cases, the vehicle shall be brought to the normal operating temperature of engine/clutch between these tests.

NOTE—The amount of extra load on the vehicle and the axles shall be as agreed by the vehicle manufacturer. In case the load requirement is excessive, the test shall be conducted at another appropriate gradient.

5.4 The starting gradeability of the vehicle, in percentage, shall be expressed as:

$$G = 100 \times \tan\{\sin^{-1}(\sin\theta \times W_T/W_R)\}$$

where

G = starting gradeability of vehicle in percentage,

θ = slope angle of the test track used for the test,

W_T = weight of the vehicle as recorded in **5.3**, and

W_R = maximum recommended GVW of the vehicle specified in **3.9**.

6 TECHNICAL SPECIFICATIONS OF THE VEHICLE

The technical specifications submitted by the vehicle manufacturer to the test agency shall contain at least the details given in Annex A.

NOTE—In case the specification submitted for whole type approval of vehicle contain the above information, it is not necessary to submit the same again.

7 CHANGES IN TECHNICAL SPECIFICATIONS

7.1 In case the testing is for the purpose of verifying compliance to the statutory limits, the changes in the technical specifications declared as specified in 6 shall be intimated to the test agency by the manufacturer. For deciding whether the changes in specifications affect the gradeability adversely or not, the guidelines given below shall be used.

7.2 In case of the following changes, the tests may be necessary for establishing compliance. However re-testing may not be required, if the conditions given at **7.4** are met.

7.2.1 Any increase in GVW.

7.2.2 Any decrease in maximum engine torque.

7.2.3 Any decrease in overall transmission ratio (engine rpm/wheel rpm) in the lowest gear (that is, the gear with highest numerical reduction ratio).

7.2.4 Any change in tyre size which increases the rolling radius.

7.2.5 Permanent 4 wheel drive to 2 wheel drive configuration.

7.3 In case of changes given in **7.2.1** to **7.2.4**, the gradeability shall be calculated for the new combination using the following formula from the results of the tested combination:

$$G_n = (T_n/T_o) \times (G_{rn}/G_{ro}) \times (GVW_o/GVW_n) \times (T_{ro}/T_{rn}) \times (G_o)$$

where

G_n = extrapolated gradeability of the modified combination,

T_n = engine torque for the modified combination,

T_o = engine torque for the combination tested,

G_{rn} = transmission ratio for the modified combination,

G_{ro} = transmission ratio for the combination tested,

GVW_o = gross vehicle weight for the combination tested,

GVW_n = gross vehicle weight for the modified combination,

T_{ro} = rolling radius of the tyre for the combination tested,

T_{rn} = rolling radius of the tyre for the modified combination, and

G_o = test result of the gradeability for the combination tested.

7.4 Conditions on which re-testing may not be required:

- G_n is more than 1.2 times the statutory limit for the gradeability or the limit specified by the manufacturer in the technical specification of the vehicle, and
- The ratio G_o/G_n is less than 1.3.

NOTE—The same procedure can be adopted for verification of the value declared by the manufacturer for the modified combination.

ANNEX A

(*Foreword* and *Clause* 6)

TECHNICAL SPECIFICATIONS OF THE VEHICLE FOR GRADEABILITY TEST

A-0 GENERAL

A-0.1 Manufacturer's Name and Address

A-0.2 Telephone/Fax No.

A-0.3 Contact Person

A-1 VEHICLE

A-1.1 Model

A-1.2 Variant

A-1.3 Type and Category of Vehicle

A-2 CONFIGURATION

A-2.1 No. of Axles:

- a) **Driven**
- b) **Non-driven**

A-2.2 Type of Drive

A-2.3 Wheel Base (mm)

A-2.4 Overhang:

- a) **Front (mm)**
- b) **Rear(mm)**

A-2.5 Angle of Approach (deg)

A-2.6 Angle of Departure (deg)

A-2.7 Ramp Angle (deg)

A-2.8 Operation of Parking Brake (Hand/Foot)

A-3 WEIGHMENT (kg)

A-3.1 Unladen Weight

A-3.2 GVW

A-3.3 Recommended Axle Load Distribution

A-3.4 Maximum Permitted Axle Load Distribution

A-3.5 Maximum Recommended Gradient

A-4 DRIVE LINE

A-4.1 Maximum Engine Torque, kg.m at ———— rpm

A-4.2 Overall Transmission Ratio Providing Maximum Torque

A-4.3 Tyre Size and Ply Rating

A-4.4 Tyre Inflation Pressure (kPa)

NOTE—The specifications as specified in **A-2.5** to **A-2.7** are required for selection of test gradient.

ANNEX B

(Foreword)

COMMITTEE COMPOSITION

Automotive Testing and Performance Evaluation Sectional Committee, TED 8

Organization	*Representative(s)*
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(*Continued on page* 6)

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